Effects of R-parity Violation on the Charged Higgs Boson Decays

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ABSTRACT

We calculate one-loop R-parity-violating couplings corrections to the processes $H^- \to \tau\bar{\nu}_\tau$ and $H^- \to b\bar{t}$. We find that the corrections to the $H^- \to \tau\bar{\nu}_\tau$ decay mode are generally about 0.1%, and can be negligible. But the corrections to the $H^- \to b\bar{t}$ decay mode can reach a few percent for the favored parameters.

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1. Introduction

The minimal supersymmeytic standard model(MSSM) takes the minimal Higgs structure of two doublets[1], which predicts the existence of three neutral and two charged Higgs bosons h^0, H^0, A^0, and $H^{\pm}$. When the Higgs boson of the Standard Model(SM) has a mass below 130-140 Gev and the h^0 of the MSSM are in the decoupling limit (which means that $H^{\pm}$ is too heavy anyway to be possibly produced), the lightest neutral Higgs boson may be difficult to be distinguished from the neutral Higgs boson of the standard model(SM). But charged Higgs bosons carry a distinctive signature of the Higgs sector in the MSSM. Therefore, the search for charged Higgs bosons is very important for probing the Higgs sector of the MSSM, and will be one of the prime objectives of the CERN Large Hadron Collider(LHC).

Current bounds on charged Higgs mass can be obtained at the Tevatron, by studying the top decay $t \to bH^+$, which already eliminates some region of parameter space [2], whereas the combined LEP experiments gives a low bounds approximately $m_{H^+} > 78.6$GeV at 95%CL[3]. In the MSSM, we have $m_{H^{\pm}} \geq 120$ GeV from the mass bounds from LEP–II for the neutral pseudoscalar A^0 of the MSSM ($m_{A^0} \geq 90.5$ GeV)[4].

Decays of a charged Higgs boson have been studied in the literature[5], which have shown that the dominate decay modes of the charged Higgs boson for large $\tan\beta$ are $H^{\pm} \to tb$ and $\tau\nu_\tau$, while $H^{\pm} \to tb$, $\tau\nu_\tau$ and Wh for small $\tan\beta$. For example, for $m_{H^+} = 250$ GeV, we have $Br(H^+ \to t\bar{b}) = 0.90$ and $Br(H^+ \to \tau^+\nu_\tau) = 0.06$ for $\tan\beta = 5$, and $Br(H^+ \to t\bar{b}) = 0.64$ and $Br(H^+ \to \tau^+\nu_\tau) = 0.36$ for $\tan\beta = 30$. Moreover, if charged Higgs boson mass $m_{H^{\pm}}$ is very heavy, the decay of $H^{\pm}$ into $\tilde{\chi}_i^{\pm}\tilde{\chi}_j^0$ are also important[6].

For all these decay channels, the one-loop Electroweak, QCD and SUSY-QCD corrections have been studied in detail in the previous literatures, for example see [7]. However, those one-loop effects were studied only in the MSSM with the discrete multiplicative symmetry of R-parity[8], and without R-parity, the effects of one-loop R-parity violating couplings on the decays of charged Higgs boson have not reported in

the literatures so far. In this paper, we try to fill this gap and present the calculation of the R-parity violating effects to the process $H^- \to b\bar{t}$ and $H^- \to \tau\bar{\nu}_\tau$, which arise from the virtual effects of R-parity Violating couplings. The most general superpotential of the MSSM consistent with the $SU(3)\times SU(2)\times U(1)$ symmetry and supersymmetry contains R-violating interactions, which are given by[9]

$$\mathcal{W}_{\not{R}} = \frac{1}{2}\lambda_{ijk}L_iL_jE_k^c + \lambda'_{ijk}\delta^{\alpha\beta}L_iQ_{j\alpha}D_{k\beta}^c + \frac{1}{2}\lambda''_{ijk}\varepsilon^{\alpha\beta\gamma}U_{i\alpha}^cD_{j\beta}^cD_{k\gamma}^c + \mu_iL_iH_2. \tag{1}$$

Here $L_i(Q_i)$ and $E_i(U_i, D_i)$ are, respectively, the left-handed lepton (quark) doublet and right-handed lepton (quark) singlet chiral superfields, and $H_{1,2}$ are the Higgs chiral superfields. The indices i, j, k denote generations and α β and γ are the color indices, and the superscript c denotes charge conjugation. The λ and λ' are the coupling constants of L(lepton number)-violating interactions and λ'' those of B(baryon number)-violating interactions. The non-observation (so far) of the proton decay imposes very strong constraints on the product of L-violating and B-violating couplings. It is thus conventionally assumed in the phenomenological studies that only one type of these interactions (either L- or B-violating) exists. Some constraints on these R-parity violating couplings have been obtained from various analysis of their phenomenological implications based on experiment[10].

2. Calculations

The tree-level amplitudes of the two decay modes of charged Higgs boson, as shown in Fig.1(a), are given by

$$M_1^{(0)} = \frac{ie\tan\beta m_\tau}{\sqrt{2}m_W s_W}\bar{u}_\tau P_L v_\nu \tag{2}$$

for $H^- \to \tau\bar{\nu}_\tau$, and

$$M_2^{(0)} = \frac{ie}{\sqrt{2}m_W s_W}\bar{u}_b(m_b\tan\beta P_L + m_t/\tan\beta P_R)v_t \tag{3}$$

for $H^- \to b\bar{t}$, where $s_W \equiv \sin\theta_W = 1 - m_W^2/m_Z^2$, $P_{R,L} \equiv (1\pm\gamma_5)/2$.

The above amplitudes lead to the tree-level decay width of the form

$$\Gamma_s^{(0)} = \frac{\overline{\sum}|M^{(0)}|^2\lambda^{1/2}(m_{H^-}^2, a_s^2, b_s^2)}{16\pi m_{H^-}^3}, \tag{4}$$

where $\overline{\sum}|M^{(0)}|^2$ is the squared matrix element, which has been summed the colors and spins of the out going particles, $\lambda(x,y,z) = (x-y-z)^2 - 4yz$, and s=(1,2) corresponds to the decays into $\tau\bar{\nu}_\tau, b\bar{t}$, with $a_1 = m_\tau$, $b_1 = 0$, and $a_2 = m_b$, $b_2 = m_t$, respectively.

Feynman diagrams contributing to the R-parity violating corrections to $H^- \to \tau\bar{\nu}_\tau, b\bar{t}$ are shown in Fig.1(b)–(c).

We carried out the calculation in the t'Hooft-Feynman gauge and used dimensional reduction, which preserves supersymmetry, for regularization of the ultraviolet divergences in the virtual loop corrections using the on-mass-shell renormalization scheme[11], in which the fine-structure constant α_{ew} and physical masses are chosen to be the renormalized parameters, and finite parts of the counterterms are fixed by the renormalization conditions. The coupling constant g is related to the input parameters e, m_W, and m_Z via $g^2 = e^2/s_W^2$ and $s_w^2 = 1 - m_w^2/m_Z^2$.

The relevant renormalization constants in the calculations of the processes $H^- \to \tau\bar{\nu}_\tau, b\bar{t}$ are defined as

$$m_{f0} = m_f + \delta m_f, \quad (f = \tau, t, b) \tag{5}$$

$$\psi_{f0} = (1 + \delta Z_{fL})^{\frac{1}{2}}\psi_{fL} + (1 + \delta Z_{fR})^{\frac{1}{2}}\psi_{fR}, \quad (f = \tau, \nu, t, b) \tag{6}$$

$$\tan\beta_0 = (1 + \delta Z_\beta)\tan\beta. \tag{7}$$

For δZ_β, we use the on-shell fixing condition[12]

$$\mathrm{Im}\{\hat{\Pi}_{\mathrm{A^0Z^0}}(\mathrm{m}^2_{\mathrm{A^0}})\} = 0, \tag{8}$$

where $\hat{\Pi}_{A^0Z^0}(m^2_{A^0})$ is the renormalized self–energy for the mixing of the pseudoscalar Higgs boson A^0 and the Z^0 boson, then we have

$$\delta Z_\beta = \mathrm{Im}\{\Pi_{\mathrm{A^0Z^0}}(\mathrm{m}^2_{\mathrm{A^0}})\}/(\mathrm{m_{Z^0}}\sin 2\beta). \tag{9}$$

Apparently, there are no R-parity violating contributions to $\Pi_{A^0Z^0}$ in our case, which leads to $\delta Z_\beta = 0$.

Taking into account the R-parity violating corrections, the renormalized amplitudes for $H^- \to \tau\bar{\nu}_\tau, b\bar{t}$ can be written as

$$M_s^{ren} = M_s^{(0)} + \delta M_s^{(v)} + \delta M_s^{(c)}, \tag{10}$$

where $\delta M_s^{(v)}$ and $\delta M_s^{(c)}$ are the vertex corrections and the counterterms, respectively. The calculations of the vertex corrections from Fig.1(b)-1(c) result in

$$\begin{aligned}
\delta M_{s=1}^{(v)} = & \frac{ig}{16\sqrt{2}\pi^2 m_W}(\lambda'_{333})^2\Big\{\sum_{m=1}^{2}\bar{u}_\tau\{[-\gamma_\mu(m_t^2/\tan\beta+m_b^2\tan\beta)C_\mu \\
& +(\not{p}_1 m_b^2\tan\beta-\not{p}_2 m_t^2/\tan\beta)C_0](m_\tau^2,m_{H^-}^2,0,m_{\tilde{b}_m}^2,m_t^2,m_b^2)\}P_L v_\nu \\
& +\sum_{m,n=1}^{2}G_{mn}\bar{u}_\tau[(\gamma_\mu P_L)C_\mu(m_\tau^2,m_{H^-}^2,0,m_b^2,m_{\tilde{t}_m}^2,m_{\tilde{b}_n}^2)]v_\nu\Big\}, \qquad (11)\\
\delta M_{s=2}^{(v)} = & \frac{ig}{16\sqrt{2}\pi^2 m_w}(\lambda''_{332})^2\Big\{\sum_{m=1}^{2}2(R_{m2}^{\tilde{s}})^2\bar{u}_b[-\gamma_\mu(m_t m_b\cot\beta+m_t m_b\tan\beta)C_\mu \\
& +(\not{p}_1 m_t m_b\cot\beta-\not{p}_2 m_t m_b\tan\beta)C_0](m_b^2,m_{H^-}^2,m_t^2,m_{\tilde{s}_m}^2,m_t^2,m_b^2)P_R v_t \\
& +\sum_{m,n=1}^{2}R_{m2}^{\tilde{t}}R_{n2}^{\tilde{b}}G_{mn}\bar{u}_b[\gamma_\mu C_\mu](m_b^2,m_{H^-}^2,m_t^2,0,m_{\tilde{t}_m}^2,m_{\tilde{b}_n}^2)P_R v_t\Big\}, \qquad (12)
\end{aligned}$$

with

$$\begin{aligned}
G_{mn} = & -m_b(\mu+A_b\tan\beta)\tan\beta R_{m2}^{\tilde{b}}R_{n1}^{\tilde{t}}-m_t(A_t+\mu\tan\beta)R_{n2}^{\tilde{t}}R_{m1}^{\tilde{b}} \\
& +m_t m_b(1+\tan^2\beta)R_{n2}^{\tilde{t}}R_{m2}^{\tilde{b}}+\Big\{[\tan\beta(m_w^2\sin 2\beta-m_b^2\tan\beta)-m_t^2]R_{m1}^{\tilde{b}}R_{n1}^{\tilde{t}}\Big\}, \qquad (13)
\end{aligned}$$

where C_0, C_μ are the three-point Feynman integrals[13], $A_{t,b}$ are soft SUSY-breaking parameters, μ is the higgsino mass parameter, $m_{\tilde{t}(\tilde{b},\tilde{s})_{1,2}}$ are the stop(sbottom, sstrange) masses, and $R^{\tilde{t}(\tilde{b})}$ are 2×2 matrix, which are defined to transform the stop(sbottom) current eigenstates to the mass eigenstates.

The counterterms can be expressed as

$$\begin{aligned}
\delta M_{s=1}^{(c)} &= \frac{ig\tan\beta m_\tau}{\sqrt{2}m_w}\left(\frac{\delta m_\tau}{m_\tau}+\frac{1}{2}\delta Z_{\tau R}+\frac{1}{2}\delta Z_{\nu L}\right)\bar{u}_\tau P_L v_\nu, \qquad (14)\\
\delta M_{s=2}^{(c)} &= \frac{ig}{\sqrt{2}m_w}\left[m_b\tan\beta\left(\frac{\delta m_b}{m_b}+\frac{1}{2}\delta Z_{bR}+\frac{1}{2}\delta Z_{tL}\right)\bar{u}_b P_L v_\nu\right. \\
&\qquad \left. +m_t\cot\beta\left(\frac{\delta m_t}{m_t}+\frac{1}{2}\delta Z_{bL}+\frac{1}{2}\delta Z_{tR}\right)\bar{u}_b P_R v_\nu\right]. \qquad (15)
\end{aligned}$$

Calculating the self-energy diagrams in Fig.2, we can get the explicit expressions of the renormalization constants as follows:

$$\begin{aligned}
\frac{\delta m_\tau}{m_\tau} &= \frac{1}{32\pi^2}(\lambda'_{333})^2\times \\
& \sum_{m=1}^{2}\Big\{(R_{m1}^{\tilde{t}})^2[B_1+B_0](m_\tau^2,m_{\tilde{t}_m}^2,m_b^2)+(R_{m2}^{\tilde{b}})^2[B_1+B_0](m_\tau^2,m_{\tilde{b}_m}^2,m_t^2)\Big\},
\end{aligned}$$

$$(16)$$

$$\delta Z_R^{\tau} = -\frac{m_\tau^2}{16\pi^2}(\lambda'_{333})^2 \times \sum_{m=1}^{2}\left\{(R^{\tilde{t}}_{m1})^2[B'_1+B'_0](m_\tau^2,m_{\tilde{t}_m}^2,m_b^2)+(R^{\tilde{b}}_{m2})^2[B'_1+B'_0](m_\tau^2,m_{\tilde{b}_m}^2,m_t^2)\right\}, \quad (17)$$

$$\delta Z_L^{\nu} = \frac{-1}{16\pi^2}(\lambda'_{333})^2 \times \sum_{m=1}^{2}\left\{(R^{\tilde{b}}_{m1})^2[B_1+B_0](0,m_{\tilde{b}_m}^2,m_b^2)+(R^{\tilde{b}}_{m2})^2[B_1+B_0](0,m_{\tilde{b}_m}^2,m_b^2)\right\}, \quad (18)$$

$$\frac{\delta m_b}{m_b} = \frac{1}{16\pi^2}(\lambda''_{332})^2 \times \sum_{m=1}^{2}\left\{(R^{\tilde{s}}_{m2})^2[B_1+B_0](m_b^2,m_{\tilde{s}_m}^2,m_t^2)+\frac{1}{4}(R^{\tilde{t}}_{m2})^2[B_1+B_0](m_b^2,m_{\tilde{t}_m}^2,m_s^2)\right\}, \quad (19)$$

$$\delta Z_{bL} = -\frac{m_b^2}{8\pi^2}(\lambda''_{332})^2 \times \sum_{m=1}^{2}\left\{(R^{\tilde{s}}_{m2})^2[B'_1+B'_0](m_b^2,m_{\tilde{s}_m}^2,m_t^2)+\frac{1}{4}(R^{\tilde{t}}_{m2})^2[B'_1+B'_0](m_b^2,m_{\tilde{t}_m}^2,m_s^2)\right\}, \quad (20)$$

$$\begin{aligned}\delta Z_{bR} = & -\frac{1}{8\pi^2}(\lambda''_{332})^2 \times \sum_{m=1}^{2}\left\{(R^{\tilde{s}}_{m2})^2[B_1+B_0](m_b^2,m_{\tilde{s}_m}^2,m_t^2)+\frac{1}{4}(R^{\tilde{t}}_{m2})^2[B_1+B_0](m_b^2,m_{\tilde{t}_m}^2,m_s^2)\right\} \\ & -\frac{m_b^2}{8\pi^2}(\lambda''_{332})^2 \times \sum_{m=1}^{2}\left\{(R^{\tilde{s}}_{m2})^2[B'_1+B'_0](m_b^2,m_{\tilde{s}_m}^2,m_t^2)+\frac{1}{4}(R^{\tilde{t}}_{m2})^2[B'_1+B'_0](m_b^2,m_{\tilde{t}_m}^2,m_s^2)\right\},\end{aligned} \quad (21)$$

$$\frac{\delta m_t}{m_t} = \frac{1}{16\pi^2}\sum_{m=1}^{2}(\lambda''_{332})^2(R^{\tilde{s}}_{m2})^2[B_1+B_0](m_t^2,m_{\tilde{s}_m}^2,m_b^2), \quad (22)$$

$$\delta Z_{tL} = -\frac{m_t^2}{8\pi^2}\sum_{m=1}^{2}(\lambda''_{332})^2(R^{\tilde{s}}_{m2})^2[B'_1+B'_0](m_t^2,m_{\tilde{s}_m}^2,m_b^2), \quad (23)$$

$$\begin{aligned}\delta Z_{tR} = & -\frac{1}{8\pi^2}\sum_{m=1}^{2}(\lambda''_{332})^2(R^{\tilde{s}}_{m2})^2[B_1+B_0](m_t^2,m_{\tilde{s}_m}^2,m_b^2) \\ & -\frac{m_t^2}{8\pi^2}\sum_{m=1}^{2}(\lambda''_{332})^2(R^{\tilde{s}}_{m2})^2[B'_1+B'_0](m_t^2,m_{\tilde{s}_m}^2,m_b^2),\end{aligned} \quad (24)$$

where B_0, B_1 are the two-point Feynman integrals[13], and $B_1'(p^2, m_1^2, m_2^2) = \partial B_1/\partial p^2$, $B_0'(p^2, m_1^2, m_2^2) = \partial B_0/\partial p^2$.

Above we have shown the expressions of the contributions from the couplings λ'_{333} and λ''_{332}, while the ones from the couplings λ'_{331}, λ'_{332} and λ''_{331} are similar, and can be obtained straightforwardly by substituting the corresponding particle masses.

Finally, the renormalized decay width is then given by

$$\Gamma_s = \Gamma_s^{(0)} + \delta\Gamma_s^{(v)} + \delta\Gamma_s^{(c)} \tag{25}$$

with

$$\delta\Gamma_s^{(h)} = \frac{\lambda^{1/2}(m_{H^-}^2, a_s^2, b_s^2)}{8\pi m_{H^-}^3}\mathrm{Re}\{\sum M_s^{(0)*}\delta M_s^{(h)}\} \qquad (h = v, c). \tag{26}$$

3. Numerical results and conclusions

We now present some numerical results for the R-parity violating effects on the processes $H^- \to b\bar{t}$ and $H^- \to \tau\bar{\nu}_\tau$. The SM input parameters in our calculations were taken to be $\alpha_{ew}(m_Z) = 1/128.8$, $m_W = 80.419$GeV and $m_Z = 91.1882$GeV[14], and $m_t = 178.0$GeV[15] and $m_b(m_b) = 4.25$GeV[16].

In our calculation, we take the running mass $m_b(Q)$ and $m_t(Q)$ evaluated by the NLO formula [17]:

$$\begin{aligned} m_b(Q) &= U_6(Q, m_t)U_5(m_t, m_b)m_b(m_b), \\ m_t(Q) &= U_6(Q, m_t)m_t(m_t). \end{aligned} \tag{27}$$

The evolution factor U_f is

$$\begin{aligned} U_f(Q_2, Q_1) &= \left(\frac{\alpha_s(Q_2)}{\alpha_s(Q_1)}\right)^{d^{(f)}}\left[1 + \frac{\alpha_s(Q_1) - \alpha_s(Q_2)}{4\pi}J^{(f)}\right], \\ d^{(f)} &= \frac{12}{33 - 2f}, \qquad J^{(f)} = -\frac{8982 - 504f + 40f^2}{3(33 - 2f)^2}. \end{aligned} \tag{28}$$

In addition, in order to improve the perturbation calculations, especially for large $\tan\beta$, we made the following replacement in the tree-level couplings [17]:

$$m_b(Q) \quad \to \quad \frac{m_b(Q)}{1+\Delta m_b}, \tag{29}$$

$$\begin{aligned}\Delta m_b = {} & \frac{2\alpha_s}{3\pi} M_{\tilde{g}} \mu \tan\beta I(m_{\tilde{b}_1}, m_{\tilde{b}_2}, M_{\tilde{g}}) + \frac{h_t^2}{16\pi^2} \mu A_t \tan\beta I(m_{\tilde{t}_1}, m_{\tilde{t}_2}, \mu) \\ & -\frac{g^2}{16\pi^2} \mu M_2 \tan\beta \sum_{i=1}^{2} \left[(R_{i1}^{\tilde{t}})^2 I(m_{\tilde{t}_i}, M_2, \mu) + \frac{1}{2} (R_{i1}^{\tilde{b}})^2 I(m_{\tilde{b}_i}, M_2, \mu) \right]\end{aligned} \tag{30}$$

with

$$I(a,b,c) = \frac{1}{(a^2-b^2)(b^2-c^2)(a^2-c^2)} (a^2 b^2 \log\frac{a^2}{b^2} + b^2 c^2 \log\frac{b^2}{c^2} + c^2 a^2 \log\frac{c^2}{a^2}), \tag{31}$$

where M_2 is the parameter in the chargino and neutralino matrix, and in our calculation, we always set $M_2 = 200\text{GeV}$. $m_{\tilde{g}}$ is the gluino mass, which is related to M_2 by $m_{\tilde{g}} = (\alpha_s(m_{\tilde{g}})/\alpha_2) M_2$[18].

The two-loop leading-log relations[19] of the neutral Higgs boson masses and mixing angles in the MSSM were used. For m_{H^-} the tree-level formula was used.

Other parameters are determined as follows:

(i) For the parameters $m^2_{\tilde{Q},\tilde{U},\tilde{D}}$ and $A_{t,b}$ in squark mass matrices

$$M_{\tilde{q}}^2 = \begin{pmatrix} M_{LL}^2 & m_q M_{LR} \\ m_q M_{RL} & M_{RR}^2 \end{pmatrix} \tag{32}$$

with

$$\begin{aligned} M_{LL}^2 &= m_{\tilde{Q}}^2 + m_q^2 + m_Z^2 \cos 2\beta (I_q^{3L} - e_q \sin^2\theta_W), \\ M_{RR}^2 &= m_{\tilde{U},\tilde{D}}^2 + m_q^2 + m_Z^2 \cos 2\beta e_q \sin^2\theta_W, \\ M_{LR} = M_{RL} &= \begin{pmatrix} A_t - \mu\cot\beta & (\tilde{q}=\tilde{t}) \\ A_b - \mu\tan\beta & (\tilde{q}=\tilde{b}) \end{pmatrix}, \end{aligned} \tag{33}$$

to simplify the calculation we assumed $M_{\tilde{Q}} = M_{\tilde{U}} = M_{\tilde{D}}$ and $A_t = A_b$, and we used $m_{\tilde{t}_1}$, $m_{\tilde{b}_1}$, $A_t = A_b$ and μ as the input parameters. We also assume $m_{\tilde{d}_{1,2}} = m_{\tilde{s}_{1,2}} = m_{\tilde{b}_{1,2}} + 500\text{GeV}$, and $m_{\tilde{u}_{1,2}} = m_{\tilde{c}_{1,2}} = m_{\tilde{t}_{1,2}} + 500\text{GeV}$. Such assuming of the relation

between the squark masses is done merely for simplicity, and actually, our numerical results are not sensitive to the squark masses of the first and second generation.

(ii)According to the experimental upper bound on the couplings in the R-parity violating interaction[10], we take the relevant R-parity violating parameters as $\lambda'_{333} = \lambda'_{332} = \lambda'_{331} = 0.3$, $\lambda''_{323} = -\lambda''_{332} = 0.9$,$\lambda''_{313} = -\lambda''_{331} = 0.9$, the remainder values of λ' and λ'' are set to zero. Otherwise, the numerical results may become small because of the cancellation among the contributions of the involved different λ' and λ'' parameters.

Fig.3 presents the dependence of the tree level decay widths on m_{H^-}, where we have included the QCD and SUSY running effects of top and bottom quark masses. From this Figure one sees that tree level decay widths get larger with the increasing of m_{H^-}.

In Fig.4 we present the relevant R-parity violating corrections to the tree-level decay widths as the functions of m_{H^-}. In general the corrections to the $\tau\bar{\nu}$ mode are negligible small. In fact, the maximum of the corrections to $H^- \to \tau\bar{\nu}_\tau$ are of order 0.1% only. For $H^- \to b\bar{t}$, when $m_{H^-} > 230$GeV, the corrections can be larger than 4%. There are many dips and peaks on the curves, arising from the threshold effects from the vertex corrections at the threshold point $m_{H^-} = m_{\tilde{t}_i} + m_{\tilde{b}_j}$. For example, as shown in Fig.4(2), at $m_{H^-} = 245.9$GeV, we have $m_{H^-} = m_{\tilde{t}_1} + m_{\tilde{b}_1}$ for $\tan\beta = 40$, and the correction to $H^- \to b\bar{t}$ can get its maximal value of 10%.

Fig.5 show the dependence of the R-parity violating corrections on $m_{\tilde{t}_1}$. In general, the corrections increase with the decreasing of $m_{\tilde{t}_1}$. For example, when $m_{\tilde{t}_1} = 100$GeV, the correction to $H^- \to \tau\bar{\nu}_\tau$ is 0.4% for $\tan\beta = 4$, while the one to $H^- \to b\bar{t}$ is 4% for $\tan\beta = 40$, and when $m_{\tilde{t}_1} = 300$GeV, above corrections are both about 0.1%.

In Fig.6 we present the R-parity violating corrections as a function of $\tan\beta$. We find that the corrections are relatively larger for low and high values of $\tan\beta$, respectively, while become smaller for intermediate values of $\tan\beta$, which is due to the fact that there are no enhanced effects from the Yukawa couplings $H^-b\bar{t}$ and $H^-\tilde{t}\tilde{b}$

at medium $\tan\beta$.

In conclusion, we have calculated the R-parity violating effects on the processes $H^- \to \tau\bar{\nu}_\tau$ and $H^- \to b\bar{t}$. These corrections arise from the virtual effects of R-parity violating couplings. We find that the corrections to the $H^- \to \tau\bar{\nu}_\tau$ decay mode are generally about 0.1%, and can be negligible. But the corrections to the $H^- \to b\bar{t}$ decay mode can reach a few percent in our chosen parameter space. Compared to the SUSY-QCD or SUSY-EW corrections, the typical values of which can be over 10%[7], the R-parity violating effects on the process $H^- \to b\bar{t}$ are smaller, but not negligible in some region of the parameter space.

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References

[1] J.F. Gunion, H.E. Haber, G.L. Kane and S. Dawson, *The Higgs Hunter's Guide* (Addison–Wesley, Reading, 1990).

[2] D0 Collaboration, B. Abbott *et al*. Phys. Rev. Lett. **82** (1999) 4975; CDF Collaboration, F. Abe *et al*, Phys. Rev. Lett. **79** (1997) 357; CDF Collaboration et al, Phys.Rev.D.**62** (2000),012004.; D0 Collaboratio et al, Phys.Rev.Lett.**88** (2002),151803.

[3] LEP Higgs Working Group for Higgs Boson Searches Collaboration, hep-ex/0107031; For the latest combined experimental limits see: http://lephiggs.web.cern.ch/LEPHIGGS/papers/index.html

[4] M. Drees, E.A. Ma, P.N. Pandita, D.P. Roy and S.K. Vempati, Phys. Lett. **B433** (1998) 346; A.G.Akeroyd et al, hep-ph/0002288.

[5] A.Djouadi et al, Comp. Phys. Comm. **108**, (1998) 56; J.Gunion, Phys. Lett. B **32** (1994) 125; D.J.Miller et al, Phys. Rev. D **61** (2000) 055011; S.Moretti et al, Phys. Lett. B **481** (2000) 49; K.A.Assamagan et al, hep-ph/0002258, 0406013 .

[6] M.Bisset et al, DESY-00-150, TUHEP-Th-00124, RAL-TR-2000-029, December 2000.

[7] C.S.Li and R.J.Oakes, Phys. Rev. D **43** (1991) 855; J.M.Yang and C.S.Li, Phys. Rev. D **47** (1993) 2872; J.M.Yang and C.S.Li, Phys. Lett. B **497** (2000) 101; W.L.H et al, hep-ph/0107089.

[8] G.Farrar, P.Fayet, Phys. Lett. B **76** (1978) 575.

[9] S.Weinberg, Phys. Rev. D **26** (1982) 287; N.Sakai, T.Yanagida, Nucl. Phys. B **197** (1982) 133.

[10] B.Allanach et al, hep-ph/0309196,9906209,9906224; Shaouly Bar-Shalom et al, hep-ph/0201244.

[11] S. Sirlin, Phys. Rev. **D22**, 971 (1980); W.J. Marciano and A. Sirlin, *ibid.* **D22**, 2695 (1980); **D31**, 213(E) (1985); A. Sirlin and W.J. Marciano, Nucl. Phys. **B189**, 442 (1981); K.I. Aoki et al., Prog. Theor. Phys. Suppl. **73**, 1 (1982).

[12] Ayres Freitas, Talk presented at the SUSY02 conference (2002), hep-ph/0205281.

[13] A. Denner, Fortschr. Phys. 41 (1993) 4.

[14] Particle Data Group, K. Hagiwara, et al, Phys. Rev. D 66 (2002) 1.

[15] D0 Collaboration, Nature 429 (2004) 638.

[16] M. Beneke and A. Signer, Phys. Lett. B 471 (1999) 233; A.H. Hoang, Phys. Rev. D 61 (2000) 034005.

[17] M. Carena, D. Garcia, U. Nierste, C.E.M. Wagner, Nucl. Phys. B 577 (2000) 88.

[18] K. Hidaka and A. Bartl, Phys. Lett. **B501**, 78 (2001).

[19] M. Carena, M. Quirós, C.E.M. Wagner, Nucl. Phys. **B461**, 407 (1996).

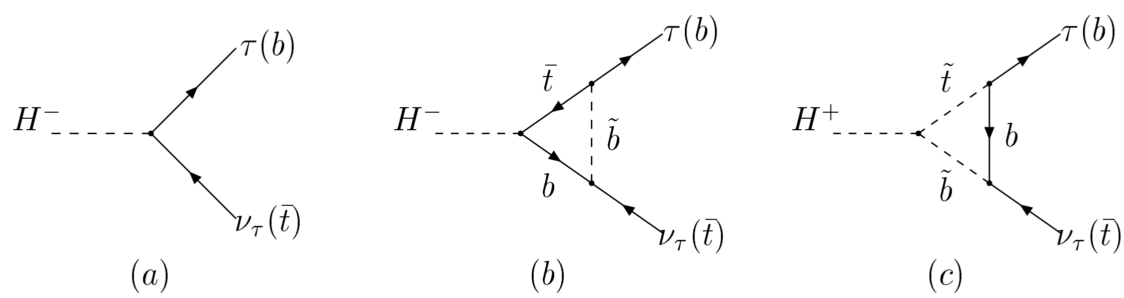


Figure 1: Feynman diagrams contributing to R-parity violating corrections to $H^- \to \tau\nu_\tau(b\bar{t})$: (a) tree-level diagram; $(b) - (c)$ are one-loop vertex corrections.

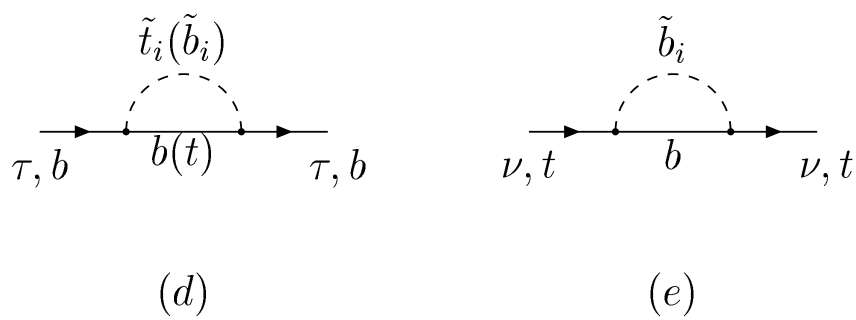


Figure 2: Feynman diagrams contributing to renormalization constants.

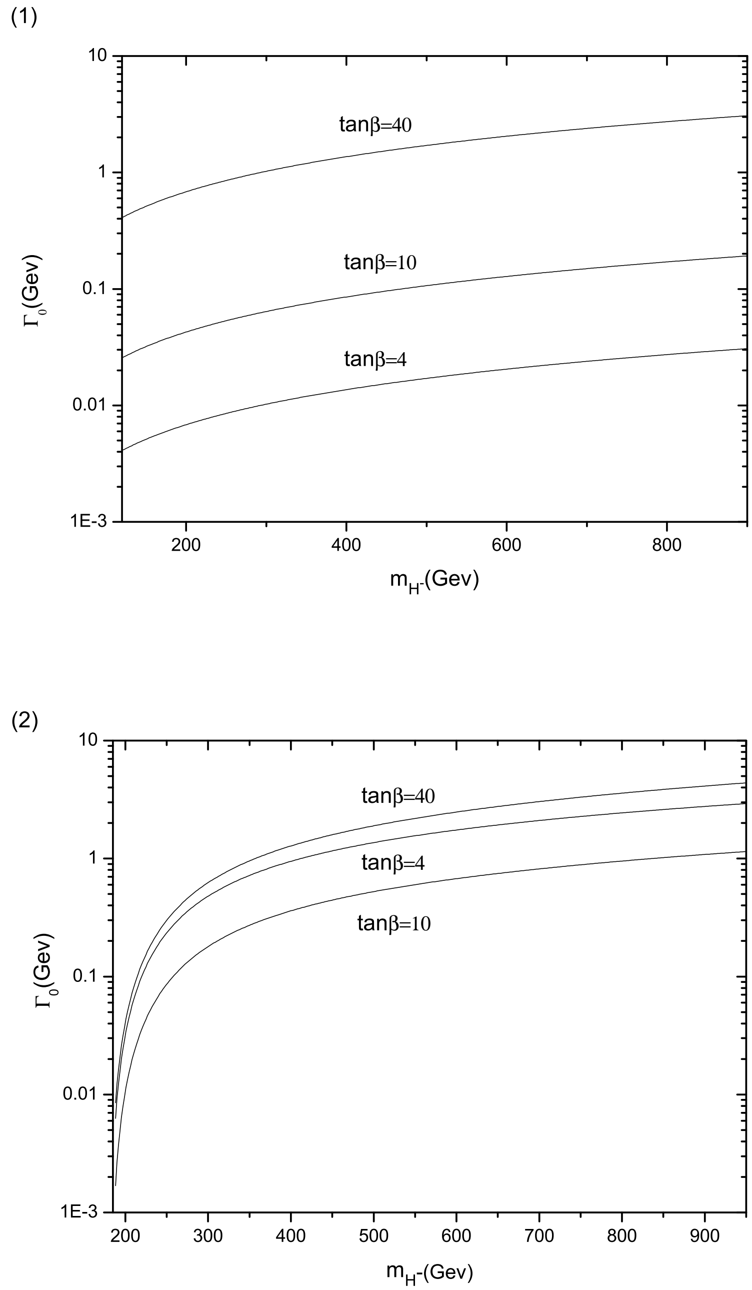
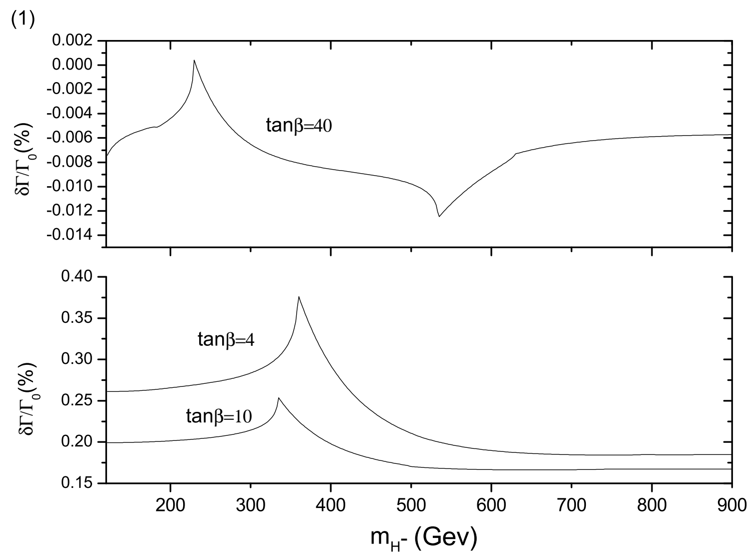


Figure 3: Dependence of the tree level decay widths on m_{H^-} for (1) $H^- \to \tau\bar{\nu_\tau}$, assuming: $\mu = -400$GeV, $A_t = A_b = 600$GeV, and $m_{\tilde{t}_1} = 100$GeV; (2) $H^- \to b\bar{t}$, assuming: $\mu = 600$GeV, $A_t = A_b = 800$GeV, and $m_{\tilde{t}_1} = 100$GeV. m_{H^-} runs from 121GeV to 900GeV and 188GeV to 900GeV for (1) and (2), respectively.



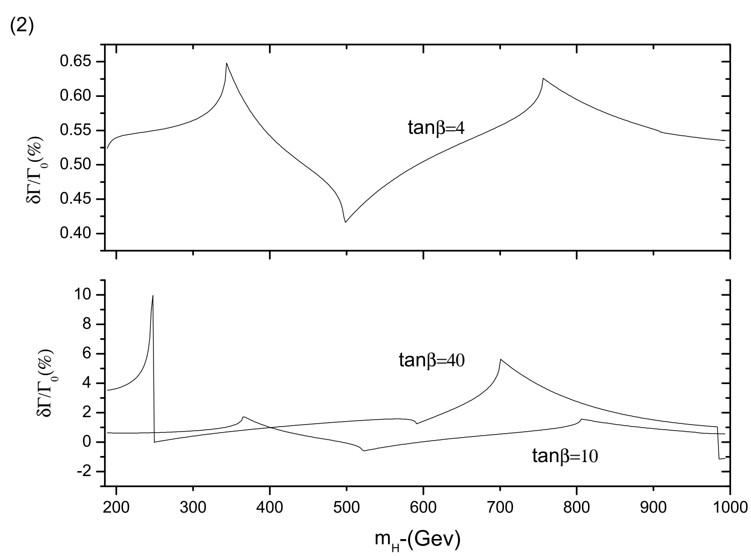


Figure 4: The R-parity violating corrections as functions of m_{H^-} for (1) $H^- \to \tau\bar{\nu_\tau}$, assuming: $\mu = -400$GeV, $A_t = A_b = 600$GeV, and $m_{\tilde{t}_1} = 100$GeV; (2) $H^- \to b\bar{t}$, assuming: $\mu = 600$GeV, $A_t = A_b = 800$GeV, and $m_{\tilde{t}_1} = 100$GeV. m_{H^-} runs from 121GeV to 900GeV and 188GeV to 900GeV for (1) and (2), respectively.

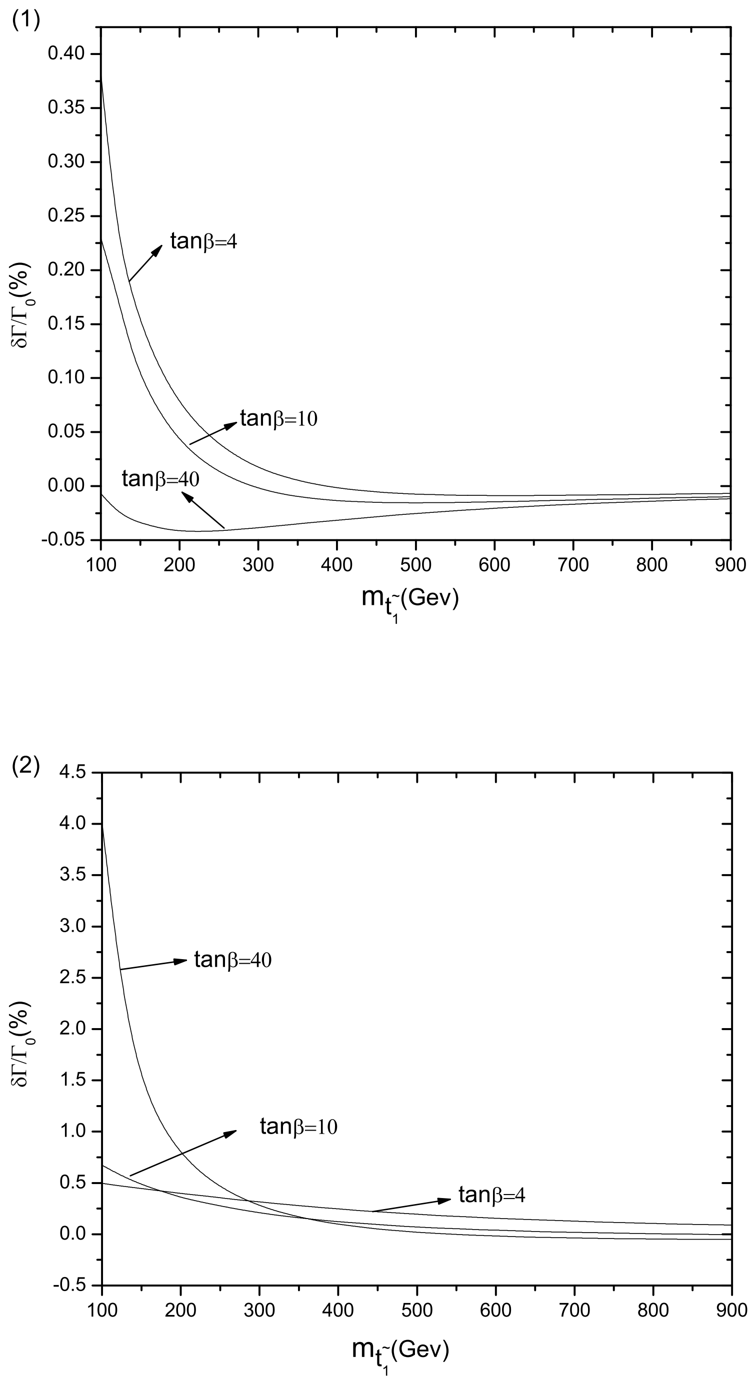
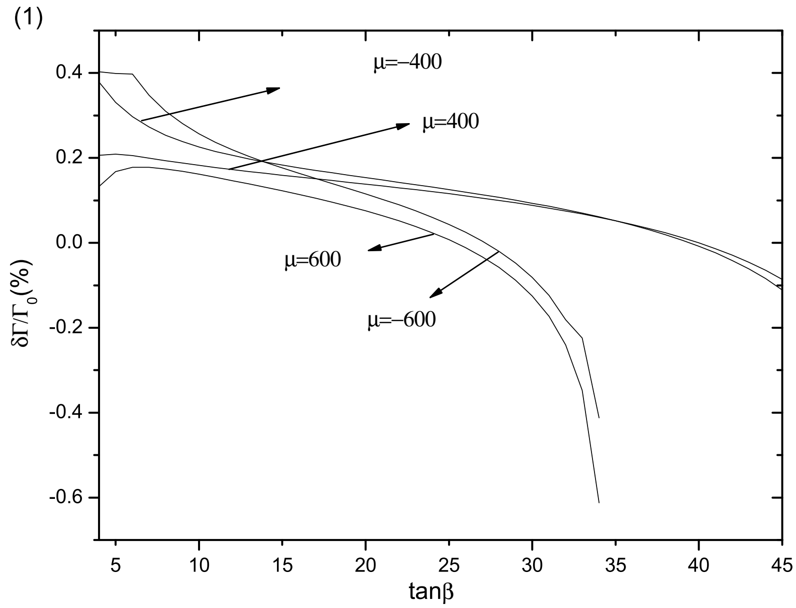


Figure 5: The R-parity violating corrections as functions of $m_{\tilde{t}_1}$ for (1) $H^- \to \tau\bar{\nu_\tau}$, assuming: $\mu = -400$GeV, $A_t = A_b = 600$GeV, and $m_{A^0} = 350$GeV; (2) $H^- \to b\bar{t}$, assuming: $\mu = 600$GeV, $A_t = A_b = 800$GeV, and $m_{A^0} = 200$GeV.



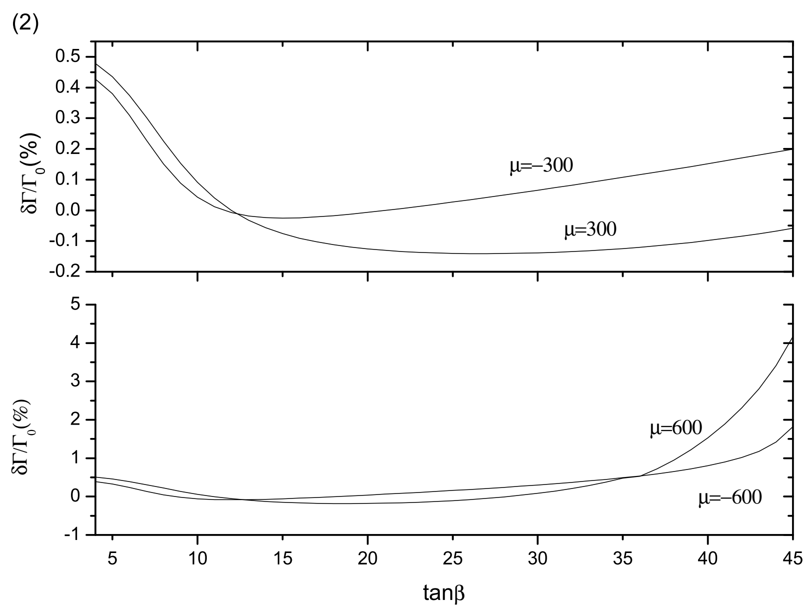


Figure 6: The R-parity violating corrections as functions of $\tan\beta$ for (1) $H^- \to \tau\bar{\nu}_\tau$, assuming: $A_t = A_b = 600$GeV, $m_{A^0} = 350$GeV, and $m_{\tilde{t}_1} = 100$GeV; (2) $H^- \to b\bar{t}$, assuming: $A_t = A_b = 800$GeV, $m_{A^0} = 600$GeV, and $m_{\tilde{t}_1} = 100$GeV.